

General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

CL 151629

INFRARED SPECTRA OF LUNAR SOILS

By J. R. Aronson, E. M. Smith, and P. G. Von Thuna

Annual Progress Report
For Period July 1, 1977, through January 1, 1978

N73-17973

Unclass
C4506

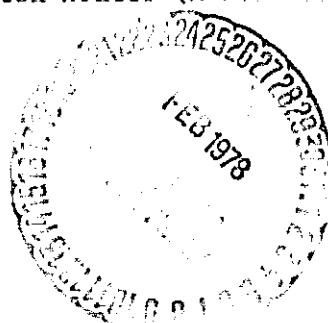
G3/91

(NASA-CR-151629) INFRARED SPECTRA OF LUNAR
SOILS Annual Progress Report, 1 Jul. 1977 -
1 Jan. 1978 (Little (Arthur D.), Inc.) 7 p
HC AC2/MF AC1 CSCI 03B

For work on lunar samples our emittance apparatus⁽¹⁾ had to be modified both optically and mechanically. The design of the sample holder was changed to allow smaller sample sizes and to prevent accidental contamination or loss of the lunar sample material.

In order to be able to work with smaller sample volumes we employ more magnification from the sample to the interferometer with an optical system that delivers a very much sharper image, thus allowing more critical definition of the sample area. The magnification of the new system is $m = 3.6$, thus imaging the detector lens of 2.3 cm diameter on the sample surface as a 6.3 mm diameter active area. Simultaneously the divergence of the cone of rays is magnified from about 3.7° half-angle at the detector to about 13.5° at the sample. However, this is still small enough to yield "normal" emittance data without significant error.

A new sample holder was designed that is better suited to protect the lunar samples from contamination, to make measurements possible on samples of less than 1 cm^3 , and to provide a better known and more uniform temperature distribution in the sample. In the new sample holder, the sample cup has a diameter of 19.05 mm and a depth of 3.0 mm so that it contains 855 mm^3 . The side walls of the sample cup are of silicone-glass tubing to provide low vertical thermal conductance. The bottom is of aluminum to provide a horizontal isothermal boundary. The aluminum block is heated by a button heater (MINCO Model H4A20W28) and

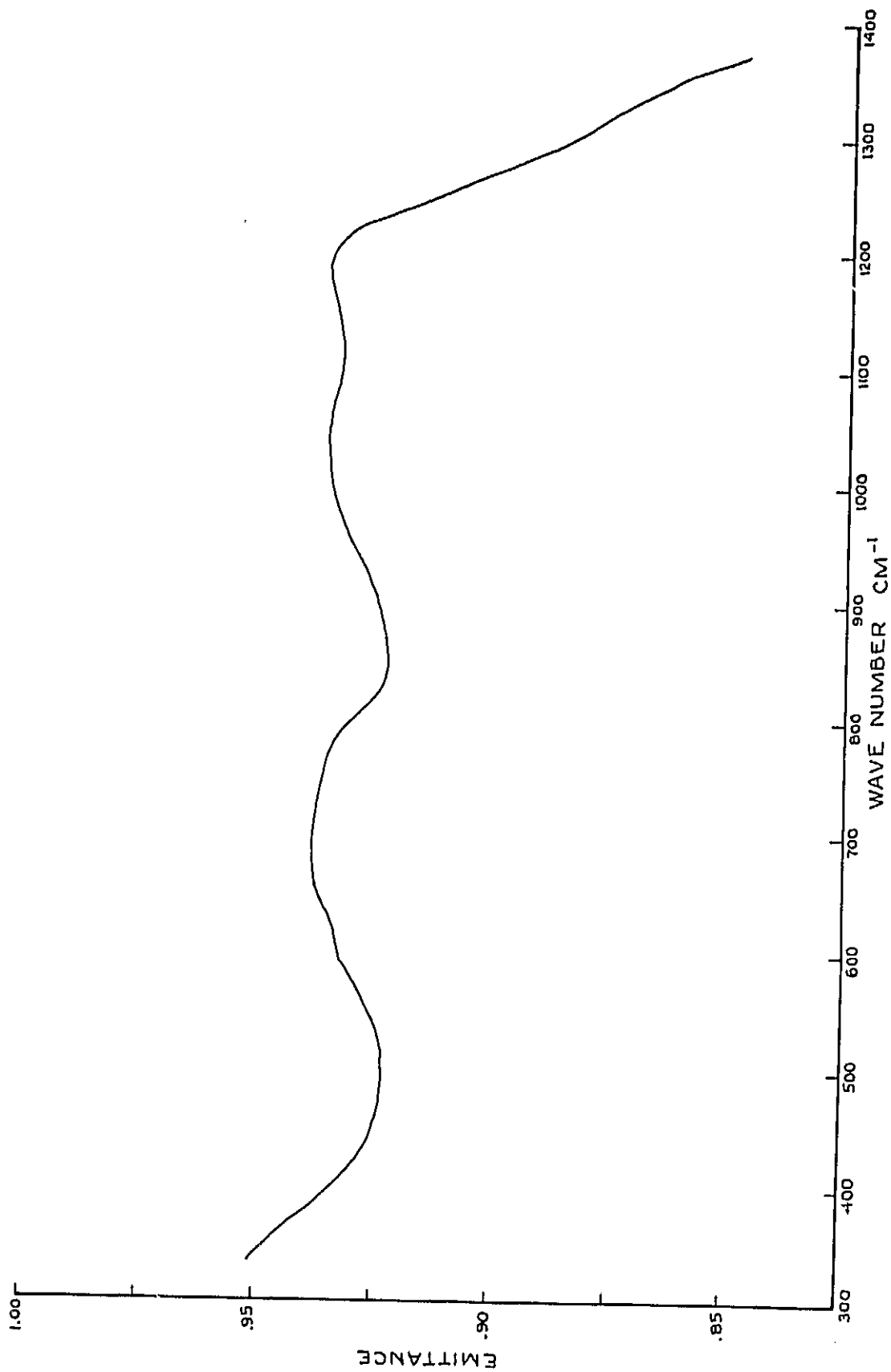


Arthur D. Little, Inc.

contains a precision thermistor (YSI Model 44030 $3000\ \Omega$ @ 25°C) in a well within 0.8 mm of the surface and in intimate contact, a reference junction of 3 mil dia. Copper-Constantan wire (Omega Engr., Inc., Stamford, Conn.). The leads from heater and thermistor are brought to terminals standing at the periphery of the sample holder's base, while the leads from the reference junction are connected with the sample junction to form a differential thermocouple, with its copper legs connected to another set of the terminals. Connection is made from these terminals via a short pigtail cable to a hermetic connector on our lazy susan and hence through the hollow shaft to the equipment outside the vacuum chamber.

Our lunar sample measurements are made both under ambient nitrogen pressure and under vacuum conditions. The measurements in nitrogen provide a nearly isothermal environment for the samples which compares well with our present theoretical development. The vacuum measurements are intended to indicate whether the presence of a steep thermal gradient such as occurs on the lunar surface will have a substantial effect on diagnostic information.

Our first measurements were made on sample 10084. This sample, when measured under an atmosphere of dry nitrogen, shows an average emittance value of about 0.9 between 300 and $122\ \text{cm}^{-1}$ (Figure 1), which is the region of the diagnostic features for silicate minerals. Three bands can readily be seen in the silicon oxygen stretching and silicon oxygen bending portions of this spectrum. These bands have very low contrast (less than .02 emittance units) but are readily measured by our apparatus. Bands are centered near $1100\ \text{cm}^{-1}$, $850\ \text{cm}^{-1}$, and $500\ \text{cm}^{-1}$ with the high frequency band being very weak. Beyond $1170\ \text{cm}^{-1}$ a steady emittance decrease to about $1400\ \text{cm}^{-1}$, which is the highest frequency in our data, is observed. This is due to the increasing transparency of the individual silicate particles beyond the "Christiansen region." The presence of the three bands indicated above confirms the predictions we made some ten years ago⁽²⁾ that diagnostic information



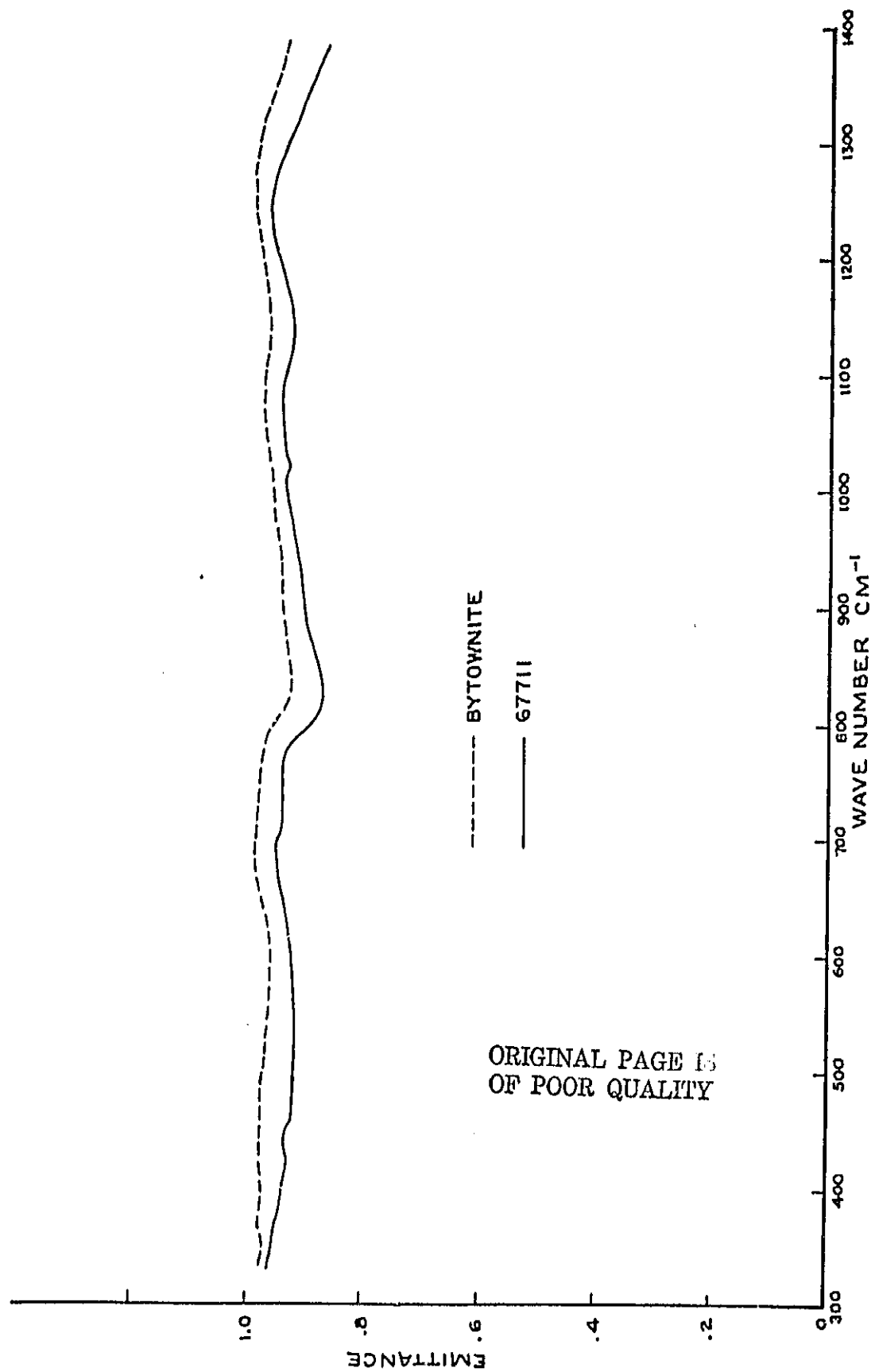
EMITTANCE SPECTRUM OF 10084

Figure 1

would necessarily be present even in the spectra of fine powders, and the low contrast shows why there is difficulty⁽³⁾ in observing the emittance features through the earth's atmosphere. The 1170 cm^{-1} Christiansen frequency is in accord with an ultramafic composition⁽⁴⁾ for the Apollo 11 soil. In addition a comparison of the data from sample 10084 with our analog results⁽⁵⁾ suggests several preliminary conclusions. First, the spectrum is similar to our analog mixture in position of features but of lower contrast. The reduced contrast may be explained by the presence of agglutinates. Our analog work indicated that a band near 830 cm^{-1} arises from fine particle feldspar, while the 1100 cm^{-1} band comes from pyroxenes.

We then made measurements on sample 67711. In this case the spectrum is quite similar to our analog results for feldspar⁽⁵⁾ (Figure 2). The discrepancy in absolute emittance level is probably due partly to temperature measurement errors in our experiment. The Christiansen frequency of 1250 cm^{-1} is again in reasonable accord with the Mafic conclusion of Salisbury et al.⁽⁴⁾ While the average emittance of this spectrum is similar to that for 10084, the contrast is about five times as great. This is to be expected from such an immature soil owing to the lack of substantial agglutinates. Both the glass content and the small metallic particles present in agglutinates are expected to reduce the spectral contrast. The glass effect was shown in our analog study.

In order to demonstrate the metal effect we have made theoretical calculations of pyroxenite spectra in which 1% by volume of iron of very small particle size was included in the theoretical simulation. The iron particles are assumed to be of the order of 100 angstroms in diameter and so are treated only as absorbers in our coarse particle theory. According to Rayleigh theory they would not be expected to contribute any scattering power to the overall mixture owing to their very small size. In our fine particle theory, however, the iron particles are treated exactly as any other component. The simulation



ORIGINAL PAGE IS
OF POOR QUALITY

EMITTANCE SPECTRUM OF 67711

Figure 2

shows that the contrast is indeed diminished compared to spectra predicted without the iron particles, principally in relatively transparent regions, but the effect is small.

The vacuum results for sample 67711 show a gross similarity to the isothermal results already discussed. There are, however, some noticeable differences in the spectrum which we are in the process of trying to understand. It is apparent that, as the radiation in any experiment originates at different depths for different frequencies owing to the differing opacities of the material at different frequencies, that the weighting function imposed by a steep gradient will have some effect on the resulting spectrum. That is, in a steep gradient case, if the underlying layers are hotter than the surface, relatively more radiation is present in transparent regions. We believe that this is the only substantial effect, but because of difficulties in measuring the real gradients involved in these samples we have been unable so far to theoretically model them precisely. In addition our experimental procedure requires that the radiance measurements we make be converted to an emittance by a knowledge of the surface temperature. This is relatively simple under the nearly isothermal conditions prevalent for a dry nitrogen run, but under vacuum conditions the measurements of the thermal gradients and the various temperatures are much more uncertain and lead to large errors in the apparent emittance level of our data.

In order to circumvent this problem we have modified our computer program used for data reduction to include an option that presents the data in terms of brightness temperature rather than emittance. This option preserves the diagnostic spectral features in the data and is not so critically dependent on surface temperature measurement. Use of this option indicates that the diagnostic information is substantially unaltered by the steep thermal gradient present under vacuum conditions.

REFERENCES

1. J. R. Aronson and A. G. Emslie, Appl. Opt. 12, 2573 (1973).
2. J. R. Aronson, A. G. Emslie, and H. G. McLinden, Science 152, 345 (1966).
3. A. F. H. Goetz, J. Geophys. Res. 73, 1455 (1968).
4. J. W. Salisbury, G. R. Hunt, and L. M. Logan, Proc. Lunar Sci. Conf. 4th, 3191 (1973).
5. J. R. Aronson, E. M. Smith, and P. F. Strong, "Infrared Spectra of Lunar Soil Analogs," Final Report on Contract NASW-2918 (July 1977).

ORIGINAL PAGE IS
OF POOR QUALITY